Nonparametric approach to analysing operational risk losses

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Motivation

- To analyze **fraud as an operational risk** for the insurance company.
- To quantify the **effect of failing to detect fraud** in a real case study.
- To apply a **nonparametric approach** to measure operational risk due to claims fraud.

Operational Risk

- According to Article 101 of the Solvency II Level 1 text:
  - The necessary capital shall correspond to the **Value-at-Risk** of the basic own funds of an insurance or reinsurance undertaking subject to a confidence level of 99.5 % over a one-year period.
- According to Article 13(33) of the Solvency II Level 1 text:
  - **Operational Risk** is the risk of loss arising from inadequate or failed internal processes, or from personnel and systems, or from external events. It refers to the possibility of unexpected events that occur as a consequence of alterations in regular functioning of companies.

Operational Risk

Difficulties:

- In insurance some events have **no physical consequences**, and therefore they are more difficult to recognize than operational failures elsewhere.
- The **lack of data**.
  - Underreporting (*undetected fraud*)
  - Large operational events are infrequent (*do insurers mainly focus on large fraudulent claims?*)

Operational Risk

- Undetected fraudulent claims is a type of operational failure.
- The absence or inefficiency of an auditing protocol can lead the insurance firm to severe aggregate losses.
- Investing in an **auditing system reduces the risk of losses** in the operational risk category, ...however the classical approach to fraud detection is usually based on a **cost-benefit analysis**.

Literature:

Dionne, Giuliano and Picard (2009 Manag. Sci.), Artís, Ayuso and Guillén (1999 IME, 2002 JRI), Viaene et al, (2002, JRI, 2007 Eur. J. Op. Res.), Pinquet, Ayuso and Guillén (2007 JRI), Crocker and Tennyson (2002 J. Law Econom.), Derrig (2002 JRI)

Fraud detection and fraud control

Different areas associated with fraud as an operational risk

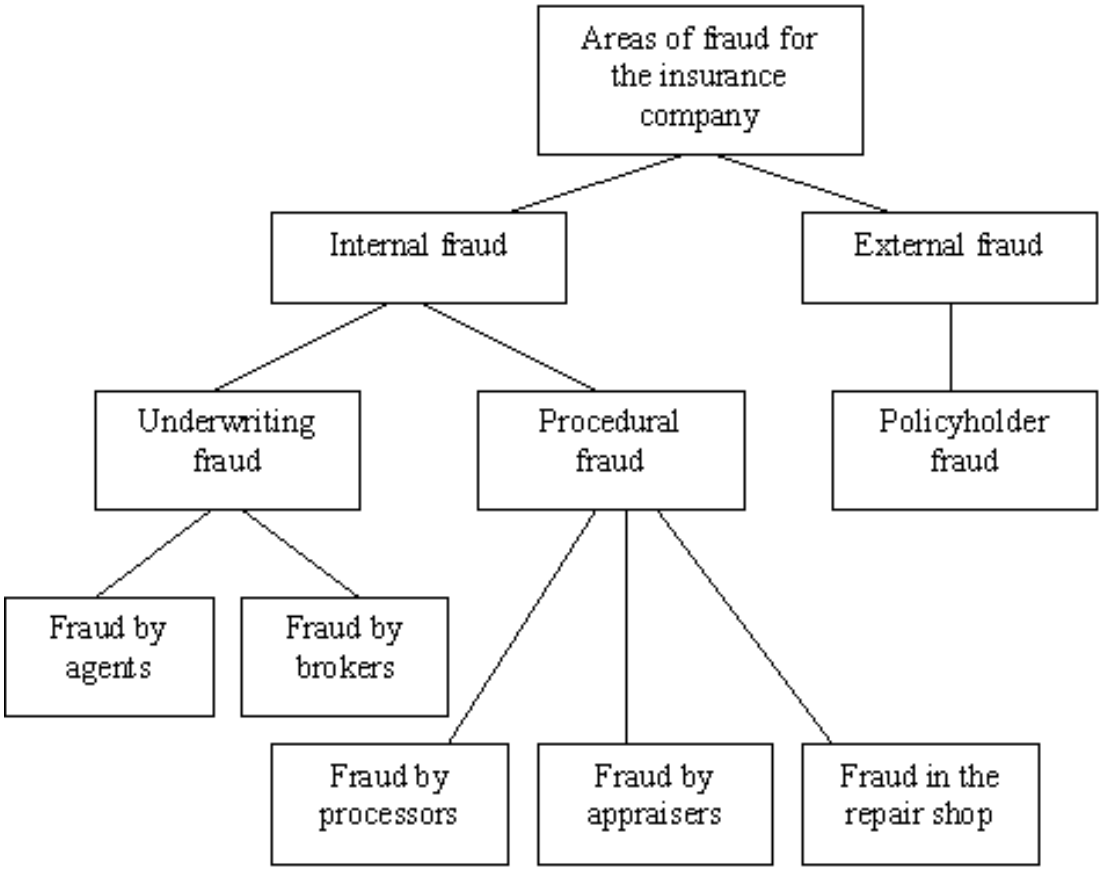


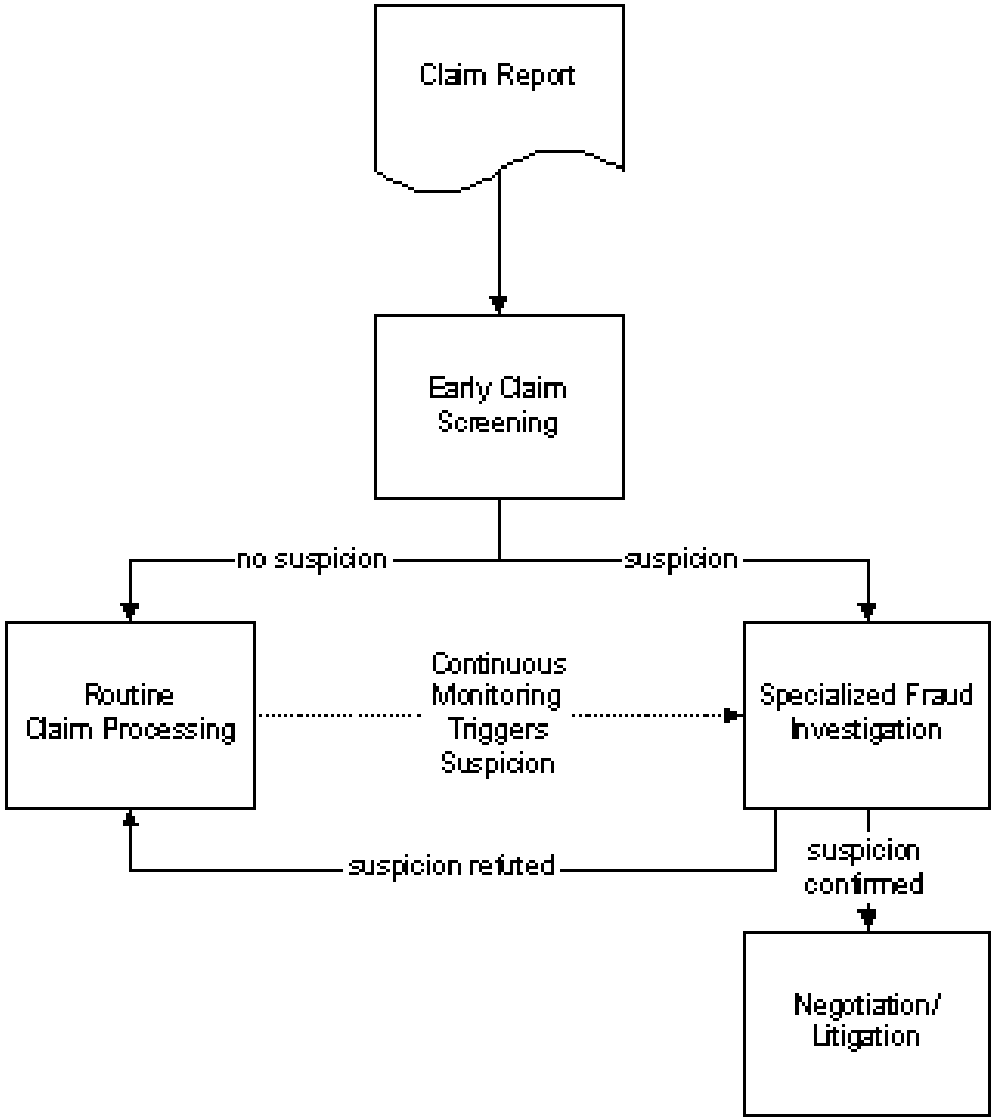
Figure: Sources of fraud for the insurance company

Fraud detection and fraud control

When aiming to detect external fraud arising from incoming claims, two possible courses of action are possible:

1. Assume that fraud exists but the insurer has **no active policy** to detect fraudulent claims or to prevent fraud.
2. Set up specialized departments to **fight against fraud** (SIUs, Special Investigation Units).

Fraud detection and fraud control



Methodology

We simulate total operational risk costs in fraud detection. The procedure is:

1. We fit the cumulative distribution function (cdf) F_X of the random variable X, which is equal to cost of a single claim associated to an operational loss. We use **the double transformed kernel estimation** of cdf.
2. We fix the **proportion of fraudulent claims** in the motor insurance claims database. We suppose:
   - Number of claims N_{Fr} can be deterministic.
   - Number of claims N_{Fr} can be stochastic.
3. We simulate the cost of the N_{Fr} claims $(x = F_X^{-1}(u))$ using the previously fitted cdf and the sum all simulated costs. We do $10,000$ replications. Then we obtain the **distribution of the total loss** due to fraudulent claims.

Methodology

Double transformed kernel estimation of cdf

$$\widehat{F}_X(x) = \frac{1}{n}\sum_{i=1}^{n} K\left(\frac{M^{-1}(T(x)) - M^{-1}(T(X_i))}{b}\right)$$

where T is the cdf of the Generalized Champernowne distribution:

$$T(x) = \frac{(x+c)^{\alpha} - c^{\alpha}}{(x+c)^{\alpha} + (M+c)^{\alpha} - 2c^{\alpha}} \tag{1}$$

and M is the cdf of $Beta(3,3)$ in the domain $(-1,1)$:

$$M(x) = \frac{3}{16}x^5 - \frac{5}{8}x^3 + \frac{15}{16}x + \frac{1}{2},\ x \in (-1,1). \tag{2}$$

Bolancé and Guillén (2011 WP), Bolancé, Guillén and Nielsen (2003, IME, 2008 Stat&Prob Letters) and Buch-Larsen et al. (2005 Statistics)

Methodology

Double transformed kernel estimation of cdf

The asymptotic mean square error (MSE) of the transformed kernel estimator or double transformed kernel estimator of cdf is:

$$\frac{F_X(x)[1-F_X(x)]}{n} - \frac{1}{T'(x)} f_X(x) \frac{b}{n} \left(1 - \int_{-1}^{1} K^2(t)\, dt\right) + \frac{1}{T'(x)} \left(1 - \frac{\frac{f_X(x)}{f'_X(x)}}{\frac{T'(x)}{T''(x)}}\right)^2 \left[\frac{1}{2} f'_X(x) \int_{-1}^{1} t^2 k(t)\, dt\right]^2 b^4. \quad (3)$$

The first two terms in (3) correspond to the variance and the last term is the squared bias. The variance part in (3) is smaller than the variance of classical kernel estimator if $T'(x) < 1$ and, on the contrary, the squared bias is larger than the bias of the classical kernel estimator.

The Data

- We use a sample taken from a **motor insurance portfolio** which was collected by a Spanish insurer and which contains information of 64,642 claims.
- The claims are about **property damages to the vehicle** and were reported during 2000; 691 claims are fraudulent, and the rest are not fraudulent.
- We assume those that are not found to be fraudulent could still contain some form of **undetected fraud**.

The Data

Table: Descriptive statistics of claims costs (in Euros)

	Average	Std. Dev.	Minimum	Median	Maximum
Non fraudulent claims (N=63,951)					
Claimed property damages (A)	**612.45**	1,178.79	0.00	333.30	63,959.71
Auditing cost (B)	**38.94**	26.65	0.00	32.42	394.77
Final compensation (C)	612.45	1,178.79	0.00	333.30	63,959.71
Total cost of claim (B+C)	651.39	1,199.02	0.00	369.59	64,011.70
Fraudulent claims (N=691)					
Claimed property damages (A)	**1,116.96**	1,486.42	49.52	696.00	17,251.83
Auditing cost (B)	**223.09**	127.12	0.00	189.91	882.45
Final compensation (C)*	7.55	88.35	0.00	0.00	1888,11
Total cost of claim (B+C)	230.64	155.87	0.00	189.98	2,271,56
All claims (N=64,642)					
Claimed property damages (A)	617.85	1,183.63	0.00	335.90	63,959.71
Auditing cost (B)	40.91	35.13	0.00	32.56	882.45
Final compensation (C)	605.99	1,174.16	0.00	330.58	63,959.71
Total cost of claim (B+C)	646.90	1,193.49	0.00	366.74	64,011.70

*Only in 8 cases the final compensation to the insured was different from zero

Results

- We estimate the 99.5% quantile of the total cost of undetected fraud.
- The percentage of undetected fraudulent claims in the insurance portfolio is thought o be around 5%, even if some special audit exists.
- We have set a series of scenario levels ranging from 0.1% to 10% for the proportion of fraudulent claims.
- We compare normal fit with nonparametric fit (double transformed estimation) and we consider deterministic and stochastic number of claims N_{Fr}.
- We calculate the auditing costs in the different scenarios of proportion of fraudulent claims.

Results

Table: Estimated 99.5% Quantile for Operational Risk (in thousand Euros)

Fraud Frequency	$VaR_{0.995}$ Normal fit N_{Fr} deterministic	$VaR_{0.995}$ Nonparametric fit N_{Fr} deterministic	$VaR_{0.995}$ Nonparametric fit N_{Fr} stochastic
0.1%	102.99	560.47	663.62
0.3%	269.93	1,581.71	1,737.66
0.5%	429.85	2,590.33	2,802.31
1%	819.37	5,059.18	5,371.40
3%	2,334.68	14,824.58	15,368.61
5%	3,827.80	24,555.51	25,168.01
6%	4,570.60	29,387.41	30,098.21
7%	5,311.73	34,208.80	34,947.18
8%	6,051.54	39,072.85	39,868.76
10%	7,528.09	48,701.35	49,780.99

N_{Fr} is the number of fraudulent claims

Results

Table: Auditing cost (in thousand Euros)

Fraud Frequency	Total auditing cost	Fraud auditing cost
0.1%	2,636.23	14.28
0.3%	2,755.19	43.06
0.5%	2,874.33	72.06
1%	2,993.29	144.11
3%	3,112.43	432.57
5%	3,231.39	721.02
6%	3,350.35	865.13
7%	3,469.49	1,009.25
8%	3,588.45	1,153.58
10%	3,707.59	1,442.03

Conclusions

- The non-detection of fraudulent claims may be a source of operational risk within an insurance company.
- According to our results, **claims auditing and detection considerably reduces operational risk**.
- The relative gain depends on the proportion of fraud in the portfolio and the cost of detecting fraud.

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